Present Status of the Fusion Neutronics Source (FNS)

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Introduction

The FNS, an intense 14 MeV neutron source for fusion neutronics studies, was completed in April 1981 at Tokai-site of Japan Atomic Energy Research Institute, and has been successfully operated for a series of the source performance tests and several experiments on fusion blanket and shielding.

A variety of neutron source conditions to meet diverse experimental requirements can be realized by pertinent combinations of each in:

a) Two ion sources — high current and low current — ,
b) Two operation modes — direct current and pulsed beam — ,
c) Two beam lines — 0° and 80° to the direction of the acceleration — and
d) Four target assemblies — dual rotating, single rotating, air or water cooled stationary targets — .

Distinctive features of the FNS are:

a) High deuteron beam current that requires special care in beam steering and target cooling,
b) High intensity energetic neutron production that necessitates pertinent accomodation both for direct radiation and induced radioactivities and
c) Considerable amount of tritium gas release from the metal target that demands for integrated design and performance of vacuum system and tritium gas removal unit as well as appropriate target handling.

The results and experiences in performance tests are reviewed in brief.

80° beam line DC operation

Initial intensity of 5 x 10^{11}n/s was achieved by max. 3 mA beam current on a 25 Ci high speed water cooled stationary target that has capability to remove up to 1.2 kW heat deposition in 15 mmø beam spot area. Neutron yield was absolutely determined with an associated alpha particle detector incorporated in the beam transport line.

80° beam line pulsed operation

In sweep mode operation, 3 mA peak current pulse was observed for the combination of the pulse width ranging in 20 ns - 8 μs and interval of 2 - 512 μs, each being varied in binary step. Minimum 1.6 ns pulse with peak current up to 45 mA at the target was obtained by bunching the 20 ns swept pulse for the pulse interval of 0,5 - 256 μs. Good on/off ratios were demonstrated in both modes. 10 Ci air cooled stationary target was adopted in the pulsed run.

0° beam line DC operation

Neutron yield of 3.2 x 10^{12}n/s was demonstrated at 20 mA target current in the performance test by using 23 cmø target disk which beared 950 Ci of tritium. Prior to the use of large tritium target, careful training operations had been repeated using blank and deuterium targets to pick up the problems in the beam handling,rotating target performance and radiation protection. 33 hr continuous operation was achieved with steady 20 mA beam at the target in this preliminary test. Improvement of original RTNS-1 type rotating target assembly was performed base on the experience in the test run.

Vacuum pump system

The vacuum pump system of the FNS consists of a storage type located next to the target assembly of each line and turbomolecular pumps in beam transport sections and in high voltage terminal. The outlet of each forepump is connected to a tritium removal equipment. The most fraction of tritium liberated from the metal target was trapped by a cryosorption pump in 0° line and a Sorb-AC pump in 80° line; the rest was evacuated differentially by successive turbomolecular pump station keeping the contamination level of the duct around the ion source several times of the background.

Tritium removal system

Tritium containing vacuum exhaust gas is transferred with the help of purging system to the removal and monitoring unit via leak free pipe lines. Gas is once kept in a storage tank through a buffer tank. Then it is recirculates in a catalyzer unit for oxidation and a molecular shieve dryer column where tritium is fixed in the form of water reducing the tritium concentration in the gas exponentially. The transference and removal of tritium gas has been done quite satisfactory and more than 100 C_i of released tritium has been processed so far with the concentration from the stack well below the regulation level.

Target temperature and beam profile monitor

A monitor system has been developed that watches the temperature distribution on the target surface under beam bombardment to prevent the excessive tritium liberation. It is a scanning infra-red ray telescope with a specially designed optical system. The thermal image of beam spot is displayed on the TV monitor for the range of 50 - 500°C. The system has shown a good and reliable performance in the target cooling capability and tritium gas release characteristics tests, and utilized effectively in routine beam adjustment.

Radiation protection

The shield structure of the FNS building was proved to satisfy the design criteria both in bulk shielding capability and in streaming prevention. The ventilation system worked well in recirculation mode to contain the activated air and keep the release at minimum. The contamination due to the handling of large amount of tritium has been kept very low by the training and observation of handling rules and by well designed equipments for target treatment.

Experiments

Two fusion blanket integral experiments on Li_2O, two streaming experiments and a activation experiment has been carried out since initial D-T neutron production in August 1981. They produced useful data in examining the nuclear data and the calculational methods used in the fusion reactor nuclear design.

References

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